DOCUMENT RESUME

ED 387 320 SE 056 584

AUTHOR Dugger, William, Jr.; Yung, J. Eldon
TITLE Technology Education Today. Fastback 380.
INSTITUTION Phi Delta Kappa Educational Foundation, Bloomington, Ind.
REPORT NO ISBN-0-87367-380-8
PUB DATE 95
NOTE 34p.
AVAILABLE FROM Phi Delta Kappa, 408 N. Union, P.O. Box 789, Bloomington, IN 47402-0789.
PUB TYPE Guides - Non-Classroom Use (055)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Elementary Secondary Education; *Science and Society; Science Education; *Technology Education
IDENTIFIERS *Science Technology Relationship

ABSTRACT

Technology education is evolving as an essential subject in schools. Because it is a new subject there are varying opinions about what technology education is and where and how it should be taught. This booklet focuses on answering questions related to technology education including those dealing with the relationship between technology and science, the current status of technology education, and the education of future citizens to live in a technological world that is becoming increasingly complex. Chapter titles include: "Technology and Science"; "What is Technology Education"; "A Historical Perspective"; "Three Levels of Technology Education" (awareness of technology, technological literacy, and technological capability); "Technology Education and the Science, Technology, Society Movement"; and "Conclusion." Resources in technology education are listed. (Contains 31 references.) (JRH)

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Technology Education Today

William Dugger, Jr.
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Technology Education Today

by
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Library of Congress Catalog Card Number 95-67074
ISBN 0-87367-380-8
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Bloomington, Indiana

This fastback is sponsored by the Virginia Polytechnic Institute and State University Chapter of Phi Delta Kappa and the Virginia Polytechnic Institute and State University Education Foundation, which made a generous contribution toward publication costs.

The chapter and foundation sponsor this fastback in memory of James D. McComas, thirteenth president of Virginia Polytechnic Institute and State University.

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Introduction

Technology is the most subtle and the most effective engineer of enduring social change. Its apparent neutrality is deceptive and often disarming.

— Robert MacIver

Technology has transformed our lives and continues to do so. While technology brings many benefits, our relationship to our creation is ambiguous. We believe that we cannot get along without technology, but we often wonder if it is getting out of hand. We now can save lives that would have ended before technology developed, but we also can destroy all life on Earth.

A major question, posed by the American Association for the Advancement of Science in its Project 2061 publication, *Technology*, is: "Who will develop and control the technologies so that they can best serve all citizens?" In a democratic society, the answer to that question must be, "an educated citizenry." Because we interact daily with technology and must make important decisions concerning its development and application, citizens must know about technology, have an appreciation of its advantages and disadvantages, and be able to use technology as an extension of human potential. Thus technology education is evolving as an essential subject in the schools.

Technology education is a new subject in the schools. In most countries, technology education is less than a decade old and still is being

developed. Because it is a new subject, there are varying opinions about what technology education is and where and how it should be taught. Some view technology education as a stand-alone curriculum. Others view it as a part of the science curriculum, while many believe that it is more closely allied with engineering. Some countries place technology education as a component of vocational education. Others believe that technology education should be integrated with mathematics, science, social studies, and other subjects. (The science-technology-society, or STS, movement is a good example of integrating technology education throughout the curriculum.) Unfortunately, many people — including educators — hold the very narrow and incomplete view that technology education is just teaching with and about computers.

The need for solid, comprehensive technology education is clear. The Committee on Education and Human Resources (CEHR) of the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET) stated:

> Citizens of the future must be equipped to make informed decisions in this age of rapidly developing knowledge, changing technology, sophisticated information, and communication systems. Accordingly, America's performance in science, mathematics, engineering, and technology must be second to none in the classroom and the workplace. (NASA 1993)

In an interview at the American Astronomical Society meeting in January 1993, Carl Sagan said it more simply: "If the United States wishes to be a world leader in manufacturing and high technology, it must have a citizenry that understands what that's about."

Key questions for educators include: What should be the relationship between technology and science? What is the current status of technology education? How should future citizens be educated to live in a technological world that is becoming increasingly complex? This fastback will focus on answering these and related questions.

Technology and Science

About 2.4 million years ago, the first humans created primitive tools by chipping away the edges of stones. Tool-making was the first technology; and it was — and is — a means to solve problems. But we have become more than just tool makers. Over the millennia, humans have refined their capability to create technological ways to solve problems.

In a very real sense, the progress of civilization has depended on the development of technology. Most often, technology has been expressed through engineering, mathematics, and other sciences. Although science and technology are different, these two, broadly defined disciplines overlap considerably. Technology is more than applied science and science is quite different from theoretical technology. Often science depends on technology to test its laws, theories, and principles. But those same laws, theories, and principles undergird the development of technology.

Students may find the following comparison chart useful in defining technology and science:

Technology	Science
Concerned with "how to."	Concerned with "what is."
Knowledge is created.	Knowledge is discovered.
Guided by trial and error.	Guided by theory.
Oriented toward action.	Oriented toward research.

The main focus of science is analysis — the breaking down of a problem into its parts — with the objective of discovering the laws of nature. Taking science courses helps to develop convergent thinking skills. On the other hand, the essence of technology is synthesis — with the objective of combining separate elements into a whole. By studying technology, one develops divergent thinking skills.

The future calls for citizens who are able to use higher-order thinking skills, such as analysis and synthesis, and creative abilities that are best acquired through understanding both technology and science.

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What Is Technology Education?

In *America's Academic Future* (1992), a report of the National Science Foundation Presidential Young Investigator Colloquium on U.S. Engineering, Mathematics and Science Education for the Year 2000 and Beyond, the authors characterized the future in this way:

> We envision a society in which the public regards science, mathematics and technology as relevant to their personal lives. Engineers, mathematicians, and scientists are perceived by the public as vital to society, and scientific and technological literacy are well defined. Engineering, mathematics, and science concepts and contributions are communicated effectively to all segments of society, principally through formal instruction in our schools and universities but also through informal out-of-class educational opportunities and programs. The public can apply the principles of science and technology to the solution of their everyday problems.

In the past decade, *technology* has shifted from tools, machines, and products to systems, problem solving, and interfacing with science and mathematics. So how do we define technology? And what is the relationship between technology and technology education?

In 1981, the Jackson's Mill Industrial Arts Curriculum theory defined technology as "the knowledge and study of human endeavors in creating and using tools, techniques, resources, and systems to manage the man-made and natural environment for the purpose of extending human potential and the relationship of these to individuals, society, and the civilization process" (Snyder and Hales 1981, *p.* 2). The def-

inition for technology in *A Conceptual Framework for Technology Education* is that it is a "body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants" (Savage and Sterry 1990, p. 2). The International Technology Education Association's latest definition, found in the January 1993 issue of *The Technology Teacher*, is:

> Technology is a body of knowledge and actions, used by people, to apply resources in designing, producing, and using products, structures and systems to extend the human potential for controlling and modifying the natural and human-made (modified) environment. (Wright and Lauda 1993)

Technology often is used as a general term to encompass all the technologies people develop and use in their lives. The United Nations Education, Scientific, and Cultural Organization defines technology as:

> the know-how and creative processes that may assist people to utilize tools, resources and systems to solve problems and to enhance control over the natural and made environment in an endeavor to improve the human condition. (UNESCO 1986)

The UNESCO definition of technology has shaped technology education in a number of nations. In Great Britain, the technology curriculum is considered a "foundation subject" that is required for all students ages 6 to 16. In the British publication, *Technology in the National Curriculum* (1990), technology is proposed as a "new" subject that requires pupils to "apply knowledge and skills to solve practical problems."

In *Technology for Australian Schools* (1992), the Australian Department of Employment and Training defines technology as the purposeful application of knowledge, experience, and resources to create processes and products that meet human needs. The needs and wants of people in particular communities determine the technology that is developed and how it is applied. People judge the desirability of technological applications by their impact on health, personal well-being and lifestyle, economies, and ecosystems.

Using a more liberal arts perspective, the U.S. Council of Independent Colleges, in *The New Liberal Learning*, defines technology as "a social process that employs scientifically — and empirically — based tools, techniques, knowledge, resources and systems to affect the human environment and its organization." It further states: "Technology includes the tools, instruments, machines, or technical formulae developed. It includes the body of ideas expressing the intent of effort, its functional importance and rationale. It also includes the systems within which skills, tools, and ideas are employed" (Lisensky, Pfnister, and Sweet 1985, p. 4).

Thus there is general agreement that technology education should be a part of the core curriculum because it is "basic" and needed by everyone. Technology education must not be confused with "educational technology or instructional technology" that *uses* technology as an enhancement to teaching.

A Historical Perspective

Because technology education is a relatively new subject in the public school curriculum, a brief historical overview may be useful. While references to *technology* can be found in U.S. education literature in the 1930s, only recently has a discernible technology education movement gained substantial momentum.

The foundation for technology education was laid over a century ago by the industrial movements in Great Britain, Western Europe, and Russia. The curriculum was called "manual training" in the United States until Charles Richards coined the name "industrial arts" in 1904. Richards, in an editorial in *Manual Training Magazine*, suggested that the term "industrial arts" be substituted for the term "manual training" because "We are rapidly leaving behind the purely disciplinary thought of manual training — now we are beginning to see that the scope of this work is nothing short of the elements of industries fundamental to modern civilization."

Most educators in the early 1900s believed that industrial arts contributed much to the general education of youth, rather than providing merely vocational job-entry skills. In 1913, Frederick Gordon Bonser, professor of Education at the Teachers College, Columbia University, expanded the concept of industrial arts, including it as a major subject in the elementary school. Bonser considered industrial arts as both subject matter and method — an end as well as a means. Later, in 1924, Bonser and Mossman developed one of the classic definitions for industrial arts in the United States:

> The industrial arts are those occupations by which changes are made in the forms of materials to increase their value for human usage. As a subject for educative purposes 'industrial arts is the study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes. (Bonser and Mossman 1924, p. 5).

The American Industrial Arts Association (AIAA) was formed in 1939 by Dr. William E. Warner; but because of World War II, it did not hold its first conference until 1947. The theme of that first conference was "A Curriculum to Reflect Technology."

The Post-War Period: 1950-1979. In 1957 Delmar W. Olson completed his Ph.D. dissertation at Ohio State University. It was titled, "Technology and Industrial Arts: A Derivation of Subject Matter from Technology with Implications for Industrial Arts Programs." This dissertation provided a direction toward a technology base for the industrial fields. As a result of this research, Olson published a book in 1963 titled, *Industrial Arts and Technology*, which stressed the challenge of technology as a source for students' discovery and development of native aptitudes and creative applications in the field of industrial arts education. One year later, in 1964, Paul W. DeVore prepared an influential monograph on the profession, *Technology: An Intellectual Discipline*, published by AIAA. This monograph laid the foundation for technology as the organizing framework for curriculum, superseding the previous industrial framework that had been used for industrial arts curricula. Like many new ideas, DeVore's philosophy was not accepted at first by many within the profession. However, it planted the seeds for later adoption.

The 1960s saw major curriculum revisions in industrial arts education in the United States. More than 20 projects were funded through federal, state, local, or foundation sources that provided rich efforts toward curriculum revision. Three influential curriculum revision efforts were the Industrial Arts Curriculum Project (IACP) at Ohio State University, the American Industry Project at Stout State Institute in Wiscon-

sin, and the Maryland Plan at the University of Maryland. Although many of these curriculum projects were influential in shaping early technology education, they usually blended an industrial and a technological curriculum foundation. The decade of the 1970s was largely an implementation period for the curriculum development efforts of the 1960s.

A Decade of Change: The 1980s. The 1980s probably created more changes in the profession than occurred over the previous century. Some efforts started in the late 1970s but were not completed until the early 1980s.

A major change effort was the Jackson's Mill Industrial Arts Curriculum Theory project, directed by James Snyder, coordinator for instructional learning systems in the West Virginia Department of Education, and James A. Hales, director of the Division of Technology at Fairmont State College in West Virginia. In addition to these two educators, 19 technology teachers, teacher educators, and supervisors from around the country met to develop a new curriculum for industrial arts education. The group sprang from two strong philosophical bases: technology and industry. After much debate and planning, the group compromised on a definition of industrial arts as "comprehensive educational programs concerned with technology, its evolution, utilization, and significance; with industry, its organization, personnel, systems, techniques, resources, and products; and their sociocultural impact." The Jackson's Mill Group's effort provided a transition from the older industrial arts philosophy to a technology philosophy.

A second major transition effort was the Standards for Industrial Arts Programs project (1978-81). Funded by a three-year grant to the industrial arts education department at Virginia Polytechnic Institute and State University, this effort was conducted by William E. Dugger Jr., Allen Bame, Charles Pinder, C. Dan Miller, LaVerne Young, David Marsh, and Lloyd Reiber. The two major thrusts of the project were to establish a national database for industrial arts and to develop national standards for quality programs in industrial arts education. From the

research that evolved through the establishment of the national database, it became clear that industrial arts programs had not changed appreciably since the early 1960s. Comparisons made with the national study by Schmitt and Pelley (1966) showed that woodwork, metalwork, and drawing were the primary courses being taught over a two-decade period. Also, the standards provided a basis for assessing the quality of programs and were later revised to be the *Standards for Technology Education* (Dugger et al. 1985).

In 1982, the American Industrial Arts Association (AIAA) formed a national advisory committee that was instrumental in bringing about reform within the association and in the profession during the 1980s. One of the key recommendations from the advisory committee was to set forth long-term goals for the association and to take a more proactive role in providing leadership for the profession. As a result, the association's elected officers formulated a three-year long-range plan for 1983 through 1986 that provided a vision for the association in this tumultuous time.

In 1984 AIAA members voted to change the organization's name to the International Technology Education Association (ITEA), effective in March 1985. (The American Industrial Arts Student Association changed its name to the Technology Student Association a few years later.) Much of the influence of the ITEA on the transition to technology education must be credited to Kendall N. Starkweather, who has served as the executive director of the association since the early 1980s.

The same year as the name change, ITEA published a document titled, *Technology Education: A Perspective on Implementation*, which provided direction to the profession in terms of making the transition. This document included a number of articles from outstanding leaders both outside and inside the profession. Strategies for implementing technology education were presented at the elementary, middle, and high school levels. Also, five models were presented that profiled existing programs of excellence in technology education at the secondary school level. That publication was followed in 1988 by *Technology Education:*

A National Imperative, which was a report by the Technology Education Advisory Council. This document was sent to all state superintendents of education in the United States and was promoted in the education community as an important transitional document for the profession toward a discipline of technology education.

In 1990, the American Association for the Advancement of Science (AAAS) published a major document titled, *Science for All Americans*. Along with this document were a number of related publications. One of those related documents, *Technology, A Report of the Technology Panel, Project 2061* (Johnson 1989) was important because it demonstrated a need for technology education as a core subject in K-12 education in addition to science and other subjects. It also was important because it was prepared by a respected association outside the technology education field.

The Decade of the 1990s. The 1990s hold opportunities and challenges for technology education. Leaders in technology education realize that technology educators must position themselves at the core of public school education.

Probably the most influential document of the present decade thus far is *A Conceptual Framework for Technology Education* (Savage and Sterry 1990). The ITEA also is fostering new efforts for federal legislation related to technology education and has developed a foundation that will allow the profession to accomplish new and different activities and to tackle research topics that will strengthen the discipline of technology education in the future.

Recently, the National Science Foundation, the U.S. Department of Energy, and the National Aeronautics and Space Administration have become involved in funding research activities and projects in technology education. Elementary school technology education has been revitalized with such projects as "Mission 21" (Brusic and Barnes 1992) funded by NASA and developed by researchers at Virginia Polytechnic Institute and State University. In addition, several states are working diligently to prepare new and innovative courses for the high school technology education programs.

The future of technology education in the United States and throughout the world is bright. However, much work still needs to be done to refine philosophies and curricula, to provide quality education for new and current technology teachers, and to research emerging technologies that future programs will need to address.

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Three Levels of Technology Education

J. Myron Atkin, in an article titled, "Teach Science for Science's Sake: For Global Competitiveness, Try Technology," said:

> The type of thinking encouraged by technology emphasizes variety and a certain divergence in intellectual effort. It is a type of thought and action seldom fostered in schools, yet it may have more to do with economic well-being than the subjects that currently dominate the curriculum.
>
> Technology, with its persistent focus on the relationship between mind and hand — with its insistence on practical work — seems closer than other subjects, including science, to the knowledge and skills necessary to improve the country's commerce and industry. But even if it weren't — even if there were not a robust link between a well-crafted technology curriculum ãnd the country's economic well-being — a solid case could be made that technology should be included in elementary and secondary schools because the knowledge it embodies is important in its own right. Practical reasoning is a universal, productive, and distinctive human activity. Emphasizing it may have the desirable effect of helping students see clearer connections between the activities they are made to do in school and the issues that make a difference in their own lives. (Atkin 1990)

Technology has become a powerful force in everyday life. Humans have the ability and responsibility to use technology to create an even better future. In order to do this, teachers must educate future citizens now to be technologically aware, literate, and capable. These three levels of technology education are keys to that better global future. And the surest way to succeed is to teach technology as a common core sub-

ject for all students, starting at the earliest age and continuing throughout formal education. Anything short of this scope will jeopardize the future of this country and of humanity.

Awareness of Technology

In *Technology Education in the Primary School*, edited by Clare Benson and Jan Raat (1993), the authors state:

> The value of technology, it can be argued, lies in the nature of the subject. It is concerned with problem solving, with active participation, with making something useful, with developing creativity and it provides a balance to the often dominant verbal character of primary education. (p. 10)

Usually, technology education at the elementary level is delivered by the regular classroom teacher. The Mission 21, Kids and Technology Program, funded by NASA and developed by the technology education program at Virginia Polytechnic Institute and State University, proposes that technology education begin at the elementary school level and extend as a well-designed and articulated program throughout the schooling experience. Mission 21 shows elementary school teachers how to use resource guides, student activities, and reference books to integrate technological concepts into their existing curricula. The program is used effectively with children of all ability levels. It enhances the elementary school curriculum through flexible problem-solving activities that correlate with science, mathematics, social studies, language arts, health and physical education, and art. The strength of the program lies in the application of the problem-solving process to a variety of technological problems, thereby increasing students' technological awareness.

Technological Literacy

In "How to Avoid Becoming a Nation of Technopeasants" (1983), R.H. Hersh states that we must acquire technological literacy as a part

of the educational experience. One definition for technological literacy comes from Franzie Loepp at Illinois State University, who said that it is the "competency to locate, sort, analyze and synthesize information that relates to achieving practical purposes through efficient action" (Loepp 1986).

A technologically literate person understands the historical role of technology in human development, the relationship between technological decisions and human values, the benefits and risks of choosing technologies, the changes occurring in current technology, and technology assessment as a method of influencing the choice of future technologies (National Science Board Commission 1984).

In 1988, the Technology Education Advisory Council of the ITEA issued a report that strongly advised establishing objectives for promoting technological literacy among all people:

> Because the American culture is distinctly characterized as technological, it becomes the function of our educational system to provide every student an insight and understanding of the technological nature of the culture. All persons must be knowledgeable of their technological environment so they can make rational decisions about their own lives on a day-to-day basis and participate in controlling their own destiny. As technological development continues at an accelerated rate, it will become increasingly difficult for people to understand these changes. Extreme action must be taken to prevent us from becoming a technologically illiterate nation. (p. 2)

Thus a technologically literate person should exhibit these characteristics:

- Awareness and understanding of how people create, use, and control their environment to solve problems and satisfy human needs and desires.
- Recognition and appreciation of the social and environmental implications of technological change and of the interaction between technology and culture, in terms of both its assets and its liabilities.

- Ability to participate intelligently in formulating questions and making decisions about technological problems in order to fulfill his or her civic responsibilities and meet professional and personal obligations.
- Ability to use technology safely and effectively to perform tasks, solve problems, and improve the quality of life. (Brusic and Barnes 1992, p. 19)

In an article defining scientific and technological literacy, Eric Bloch (1986) stated:

> Anyone who finishes high school should be able to read a newspaper or magazine article on technology-related issues of the day, such as medical research, environment, automation, or nuclear power.
>
> More important: High school graduates should be able to react to science policy issues that touch their lives not just on the basis of emotion, but on the basis of some understandings. They should be able to ask:
>
> - What are the facts?
> - What are the risks?
> - Do we know enough?
> - Who can be trusted to make the right decision and what is the decision process?
> - What are the consequences of different views?
>
> In addition, any graduate should be able to make informed choices about educational and career directions.
>
> In short, scientific and technological literacy should provide an informed basis for public decision making. Pursuit of this objective is no longer a luxury. Scientific and technological literacy is a national necessity.

The idea that a society can exist in this technological age with no higher "literacy" than the ability to read, write, and count is foolish. Literacy now includes the competence to sort, analyze, and synthesize an array of information. In the future, the difference between the

"haves" and the "have-nots" will be measured in terms of understanding technology, or becoming technologically literate (Croft 1990).

Technological Capability

In today's global economy, it is imperative that each country develop a technological work force in order to compete in the world marketplace. In *Technology Education: A National Imperative*, the authors stated:

> Students planning to pursue engineering or science in college gain much from taking selected technology education courses. Also, students will develop transferable skills for life or further education. This program complements the middle or junior high school curriculum and offers sequential courses that build on previously learned content without repetition much in the same way that senior high math or science courses build on the introductory courses offered in earlier grades.
>
> Students at this level will:
>
> - Experience the practical application of basic scientific and mathematical principles.
> - Make decisions about post-secondary technology careers, engineering programs, or service-related fields.
> - Make decisions about advanced technical education programs.
> - Gain an in-depth understanding and appreciation for technology in our society and culture.
> - Develop basic skills in the proper use of tools, machines, materials, and processes.
> - Solve problems involving the tools, machines, materials, processes, products, and services of industry and technology. (Technology Education Advisory Council 1988, p. 19)

Technology education at the high school level has been organized in numerous ways to address the many aspects of technology. Courses dealing with research and experimentation or design often introduce research activities in such areas as home insulation, pollution control, structural design, and product comparisons. Programs have been es-

tablished around emerging technologies, technological issues, frontiers of science and technology, and technical adaptive systems. Whatever the approach, the current trend in technology education is toward systematic study that develops broad and useful understandings for a more technologically literate citizenry and productive society.

The current movement called Tech Prep may have an association with technology education at the high school level. (See fastback 363 *Tech Prep: A Strategy for School Reform.*) Tech Prep involves articulated agreements between school systems and community colleges and other postsecondary institutions that connect the last two years of high school with a two-year associate degree program. Some typical high school courses that can be taught by technology teachers are "Principles of Technology," "Introduction to Engineering," "Technology Transfer," and "Technology Assessment." Further articulating this scope and sequence are programs that link the last two years of high school, the two-year community college, and the completion segment of two years at a four-year college or university, culminating in a baccalaureate degree.

Technology Education and the Science, Technology, Society Movement

For the past decade there has been a movement to place technology at the core of the liberal arts curriculum by integrating studies of science, technology, and society — or STS. Proponents of this movement come from a liberal arts tradition and believe that STS provides a more up-to-date perspective on what a person needs to be "fully educated" than the disciplines would provide if taught separately. The STS movement places the study of technology squarely in the middle of a science and social studies combined curriculum.

John Truxal, a leader in the STS movement, stated:

> If we expect our graduates to contribute to the quality of life through their individual creative work in family, jobs, and society, we need to recognize that all of us are involved in and interact with a highly technological environment, and that "education should develop his or her capability for lifelong learning in all of the disciplines which contribute to this environment. (Truxal 1984, p. 2)

The basic tenets of the STS movement were listed by George Bugliarello (1988):

> 1. Every scientific system is also a social system, defined by the goals, values, methods, organization, and practices of the scientists involved. Science as a whole is a vast social system for understanding nature.

2. Similarly, technology is a social system, because people design it, build it, and use it. Technology, as a whole, is a vast social system for modifying nature.

3. In many social systems, and therefore in many scientific and technological systems, there are a number of social sub-systems.

4. Every scientific or technological system interacts with other social systems and sub-systems.

5. The interactions between a scientific or technological system and other social systems affect the goals, values, designs, constructions, and operations of both the scientific or technological system and the social system.

6. The interfaces among the various social sub-systems of a scientific or technological system, and more generally of any social system, affects the goals, values, designs, construction, and operations of the sub-systems.

Much already has been accomplished in the STS movement in terms of curriculum development and reform. However, because it is an innovation, such changes are difficult to coordinate and to implement systematically or universally.

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Conclusion

Technology education is an emerging discipline. Its implementation must be viewed by educators as a long-term investment. It has its own subject matter, but technology education also can be used to integrate other subjects.

The study of technology is important because technology is a dominant force in contemporary life. We need to study, experience, and gain an appreciation for technology because we are surrounded by it. Because the central focus of technology education is technological literacy for all students, it must be implemented as an essential core subject.

In *Educating Americans for the 21st Century*, the authors state: "True learning includes, first, a sense of accomplishment and satisfaction; second, an excitement which generates further exploration; and, third, a desire to relate this ability to other areas. It is our position that the study of technology can stimulate this cycle and foster true learning."

If one looks toward the future, then one quickly realizes that the study of technology is an imperative.

Resources

The following list contains the names, addresses, and phone numbers of some resources in technology education:

International Technology Education Association
1914 Association Drive
Reston, VA 22091
(703) 860-2100

The National Association for Science, Technology, and Technology Materials Research Laboratory
Pennsylvania State University
University Park, PA 16802
(814) 865-1137

Technology Student Association
1914 Association Drive
Reston, VA 22091
(703) 860-9000

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